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SCIENCE EDUCATION IN THE JUNIOR COLLEGE, PROBLEMS AND PRACTICES.

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MAJOR ADDRESSES AND SUMMARIES OF GROUP ACTIVITIES FROM FOUR CONFERENCES ON TEACHING SCIENCE IN THE JUNIOR COLLEGE ARE PRESENTED. THE PRESENT STATUS OF JUNIOR COLLEGE SCIENCE IS EXAMINED AND SUGGESTIONS ARE MADE FOR IMPROVEMENT. NEW APPROACHES TO PHYSICAL SCIENCE AND BIOLOGICAL ASPECTS OF THE SPACE PROGRAM ARE CONSIDERED. WORKING GROUP REPORTS INCLUDE INFORMATION RELATED TO GENERAL EDUCATION SCIENCE, TECHNICAL EDUCATION, BIOLOGY AND PHYSICAL SCIENCE LABORATORY PROGRAMS, STUDENT BACKGROUND, AND TRANSFER STUDENTS. THIS DOCUMENT IS ALSO AVAILABLE FROM THE NATIONAL SCIENCE TEACHERS ASSOCIATION, 1201 SIXTEENTH ST., N.W., WASHINGTON, D.C. 20036, FOR $1.00. (AG)

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SCIENCE EDUCATION IN THE JUNIOR COLLEGE

PROBLEMS AND PRACTICES

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SCIENCE EDUCATION IN THE JUNIOR COLLEGE

PROBLEMS AND PRACTICES

Albert F. Eiss, Editor

A Report of Four Conferences on Junior College Science Teaching

Commission on the Education of Teachers of Science
of the
National Science Teachers Association
1201 Sixteenth Street, N. W.
Washington, D. C. 20036

The Commission on the Education of Teachers of Science of the National Science Teachers Association wishes to express its appreciation to Mary Hawkins for final editing of the manuscript, to Esther Patterson for typing it and arranging for publication, and to the other members of the NSTA staff who assisted in producing this publication.

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F-O-R-E-W-O-R-D

This publication has been prepared from materials obtained at four conferences on junior college science teaching held during the 1965-66 academic year. Several hundred teachers attended these conferences. Their enthusiasm for the speakers and for the results of discussion groups has encouraged us to publish the material. The National Science Teachers Association wishes to thank the many science instructors who assisted in conducting the meetings and in preparing the reports of the work sessions. Particular thanks goes to the many participants who, with their enthusiastic response and critical discussion, made these reports possible.

Robert H. Carleton
Executive Secretary
National Science Teachers Association

I-N-T-R-O-D-U-C-T-I-O-N

During the 1965-66 academic year, the National Science Teachers Association's Commission on the Education of Teachers of Science held four conferences on science education in junior colleges. One was held during the NSTA regional meeting in Detroit, Michigan, in cooperation with the Michigan Academy of Arts, Sciences, and Letters. Another was held during the NSTA regional meeting in Tucson, Arizona, in cooperation with the Arizona Academy of Science. The next was held during the AAAS annual meeting in Berkeley, California. The fourth and last session was an invitational meeting held in Philadelphia, Pennsylvania, in cooperation with the Pennsylvania Academy of Science.

The final meeting was designed as a working session to review and coordinate the work of the previous meetings, and to develop suggestions that would assist junior college science instructors in revising the science curriculum.

The publication consists of two parts. Part I presents some of the presentations and panel discussions that were particularly pertinent to pro[illegible] of junior colleges. Part II consists of the summaries prepared by the working groups and the conclusions that may be drawn from them.

This booklet is published as a service to the many junior college science instructors throughout the country who are dissatisfied with their present courses and wish to introduce new content, new ideas, and new teaching techniques into their curriculum. A publication of this sort can never equal the value of actual participation in such a conference, but it may be of assistance to those who were unable to attend.

Albert F. Eiss
Associate Executive Secretary
National Science Teachers Association

PART I - MAIN ADDRESSES

THE CHALLENGE TO SCIENCE EDUCATORS

J. O. Luck
Head, Education and Training
Murray Hill (New Jersey) Laboratory
Bell Telephone Company

In preparation for my role as keynote speaker, I reviewed he materials sent to me as background information for this conference. As I studied the information, it became increasingly clear hat the participants in this workshop are well informed. You have een deluged with data concerning the number of students enrolled n junior colleges, the growth of the junior college movement, the rowth of science education within the junior colleges, the number f terminal students versus the number who continue on to four-year nstitutions, and so on. It thus appears unnecessary for me to resent this wealth of data to you once more. It seems more appropriate that I appear here not with the intention of informing you ut rather with the intention of reminding you of some facets of he problems now facing science educators and science education in he junior college in particular. But to remind you of these facets nd leave you seems inappropriate unless I also remind you of a ethodology or a procedure by which you may best come to grips with he problems you have identified and upon which you will work durng the next two days.

Let me start by quoting from the report of January 11, 962 of the President's Advisory Committee on Labor Management olicy. "Our purpose then is to seek the course of action which ll encourage essential progress in the form of automation and chnological change, while meeting at the same time the social nsequences such change creates." First, let us note that this gnificant statement is from a labor-management group and not om a science-engineering group. The statement seems to remind that the leadership of this nation and, in fact, we the people e encouraging change. This is being done by increasing the instment in basic research and in development and by increasing e reservoir of manpower trained to participate in the research d development processes. The financing, as you know, is from ivate and from public sources.

The increasing support of basic research and the availility of more and more qualified people to participate in the search effort assures us of an increase in the rate at which owledge is developed. Here lies the root of one of the most rious problems facing science educators. How can you organize urselves to assimilate the new knowledge quickly and equally ickly develop new curricula and courses so that you offer an ucational program in tune with the times--an educational proam that will prepare young men and women to participate effecvely in today's society and to cope with at least today's probms? Your problem in the junior colleges in this regard is much re difficult than the same problem faced by the graduate schools even faced by bachelor's degree granting institutions. It ems to me that each of the work sessions you have identified r this workshop must consider this general question.

In my phrasing of the question, I alluded to the need to develop new courses. In this era of rapid growth in our scientific knowledge and in our technological development, we do develop new courses. In fact, we proliferate courses in narrow specializations. What are needed, however, are courses that synthesize the knowledge within each broad scientific area. Such courses are needed in order to utilize effectively the time span available, for while the body of knowledge increases, there is no indication that the time span in which the knowledge must be disseminated and absorbed will substantially change.

Not only should we seek to develop courses that synthesize the knowledge within a field such as physics or chemistry, but we should also seek to develop unified courses in science for general education as well as for the preparation of transfer students who will specialize in physics, chemistry, or biology. Such unified courses which present the fundamental principles of physics chemistry, and biology are difficult to develop, organize, and teach. Certainly not all that is now taught in biology, chemistry, and physics can be or should be included. But reasonable and knowledgeable minds can identify the essential, underlying principles, and the fundamental problems as the starting point in the development of such courses. I may be asking for too much in suggesting that biology be included at this time in such a unified course, but certainly a course containing the necessary physics and chemistry can be developed and taught.

Let me go back at this point to the Committee on Labor Management Policy where it states, "...while meeting at the same time the social consequences such change creates." As educators, what are our responsibilities in this area? Do we identify for our students some of the fundamental technological problems facing our society? These include air and water pollution, a reliable potable water supply, traffic congestion, increasing agricultural productivity, and industrial productivity. Do we identify for them the fact that current technology can solve the problems of air and water pollution, of assuring a potable water supply, and of traffic congestion? Do we discuss the legal, social, and economic factors that impede the technical solutions?

I doubt if we should include such questions in discussions within our science courses, but we should make certain that they are included in the general curricula of courses taken by our students. We know what the technological problems are, and we know the available technical solutions. We must make certain our fellow educators in the social sciences are informed and are able and willing to discuss these technological problems with our students. One possible aid in developing such understanding on the part of our fellow educators in the social sciences may be summer workshops in current problems in our society and their possible technical solutions. These workshops should be conducted by the leaders in the scientific and engineering committees.

As science educators, we tend to avoid our responsibilities for the development of courses in the history and in the philosophy of science. It seems to me that the general student

ains a great deal from such courses when they are well taught, ell organized, and up to date.

As an alternative to such separate courses in the history nd in the philosophy of science, the present classic history and hilosophy courses can be revised to include a fundamental ground- ng in the impact of scientific development and scientific thought n our history and our philosophy. Once again we may find a need o give some thought to developing programs for the re-education f our colleagues in the social sciences.

As science educators, automation is not our primary con- ern. However, it is a mistake to ignore in the development of ur courses this very important field. We can help prepare stu- nts for full participation in this automated society by encour- ging data processing and programing instruction wherever feasible. o student should be leaving junior college without being able to tilize a computer as an aid in his work. It will not be long be- ore all employees, starting with secretary and clerk and going ight up the line will need to be able to work with these data- rocessing machines.

Thus the challenges to science educators in the junior ollege movement are many and diverse. They include retaining ne's competence, developing new courses, instilling a sense of ocial responsibility in our students, helping our fellow educa- rs in other fields acquire the scientific knowledge and insight ecessary to make their courses more meaningful in this techno- gical age.

I should like now to suggest a procedure for each of the rkshop groups. Make certain that you identify the goals for ur discussion. What is the problem to which you will address urselves? Next, make certain that you have several alternative lutions and that you develop criteria by which you will evaluate e alternatives. These criteria would include boundary condi- ons such as cost, time, availability of competent staff, etc. nally, select the alternatives deemed most desirable. In brief, n't just have a bull session. You have a real opportunity to ke a contribution to science education. Make the most of it rough well organized, disciplined considerations of specific oblems.

MEETING THE CHALLENGE I

Rudolph L. Heider
Associate Professor, Chemistry
Meramec Community College, Kirkwood, Missouri

Just what is "The Challenge"? For those of us in junior college work it is how to educate large numbers of students of widely varied backgrounds, interests, and motivation to achieve independent and reasoned judgment in the sciences. I will direct my remarks to the training of the professional scientist or engineer and of the scientific technician. My training and entire career have been in chemical engineering and chemistry, with over 20 years' varied industrial experience in a large chemical corporation. Needless to say, I prefer to relate my thoughts to this industry as a prototype, since many of its technical manpower and training problems do not differ much from those of other highly technical industries.

Education is now--or soon will be--the largest "business" or enterprise in the United States. Further, the product of our schools must be able to cope with the world as it will be 10 to 20 years in the future. Long-range planning is now an important staff function in any large corporation--so it must also be in education.

For how can we educate youngsters for tomorrow unless we have a fairly good idea of what tomorrow will bring? Many educators are grappling with this problem. You may have read Dr. R. M. Hutchins' recent article in The Saturday Review entitled "Are We Educating Our Children for the Wrong Future?" I believe this might be better stated, "Are We Wrongly Educating our Children for the Future?" I certainly hope we have sufficient control of our own destiny to make the future "right"!

Let's gaze into the crystal ball to have a look at the future. First, 90 percent of all the scientists that have ever lived on earth are now alive and generating scientific information at jet speed. Second, the revolution due to automation has just begun to move out of its infancy. Third, because of the population explosion, man must eventually form a world government wherein present independent governments may become states of a new world organization. If this does not happen, it is highly probable that we are headed for another long period of dark ages wherein civilization, as we know it today, is barely able to survive.

One aspect of this complicated picture is, however, becoming quite clear, i.e., new technology resulting from automation over a reasonable number of years which were highly uncomfortable because of the extremely high rates of unemployment--will employ more people than are displaced; but those employed will have to be highly skilled and highly trained.

Look at it this way: The first revolution was the Industrial Revolution which led to relieving man of most of the

fficult, back-breaking physical labor. You will recall that e prophets of doom predicted horrible consequences of man's e of machines. This was because it is so difficult to visualize e growth of brand-new products and industries based on today's tlook. For example, consider the number of people employed and e technical skills needed in providing us with electric lights, compared with that needed for kerosene lamps.

The second revolution is now beginning to pick up momen- m, i.e., the impact of automation which will relieve man of a eat deal of mental work. Again, we shall suffer a period of sorientation until new activities will be uncovered by man. te that I stated "activities" and <u>not</u> "production or new prod- ts." The only relationship we now understand is between pro- ction and employment. If, however, 10 to 20 percent of the pulation will be able to <u>produce</u> all the material goods requir- by man, then it is obvious that this relationship will be sev- ed. The social, political, economic, and educational aspects this dissolution are staggering, and more than a little fright- ing, as viewed in October 1965. Therefore, it is highly prob- le that our students will find themselves without work as de- ned by today's thinking. Dr. Hutchins has stated, and I agree, at in any country that has a fast moving technology and a highly bile population, specific education directed at jobs is bound to ineffective.

To put it bluntly, we cannot much longer regard education a means of making individuals more efficient in the <u>art of pro-</u> <u>ction</u>. We must become more concerned with making individuals oadly educated persons.

One other aspect of science education is also coming into us, namely, that education will be a womb-to-tomb proposition. in the junior colleges will be but one line--we hope an impor- t one--in the total science education of an individual. Again, is is a reflection of the tremendous output of scientific in- mation. It is now estimated that, without further education, scientist or engineer will be obsolete in less than 10 years. atever activity the modern scientist or engineer is engaged in, will be necessary for him to devote up to 50 percent of his e on the job to the task of continuing to keep abreast of this od of information. The eschatology of this trend is staggering! haps one answer lies in knowing much more about the brain and vous system so that we might transfer electronically taped in- mation in a computer directly into the brain of an individual, entially cutting a "tape" in the brain from a master tape on a puter. Does this appeal to you as an easy way to teach ence 101?

Let's return to today--Fall 1965--and think about what are now doing in relation to the future as we see it. What, n, is the nub of our problems in education? I believe it is t we know so tragically little about the learning process, ut creativity, and about motivation. In my opinion, research these areas should assume an importance equal to that of a sile program. We have become highly efficient in a large

number of areas--particularly warfare--but what revolutionary developments have occurred in educational methods and learning processes that would hold a candle to the development of atomic physics, for example? Recall that education is--or soon will be--our largest enterprise.

Obviously, to protect this investment, we need to expend effort on basic research. The chemical industry normally spends from 3 to 5 percent of its investment per year for research. By such a yardstick the educational industry, if I may call it such, is spending an unbelievably small amount for basic research: net effect--little or no progress! We have been proud of the growth of the sciences over the past 50 years. Yet, after being away from the college laboratory for almost 25 years, I am shocked to find that the laboratories of today are almost a carbon copy of those I left 25 years ago. To be sure, we now make good use of plastics, pastel colors, and modern design but, <u>educationally</u>, there has been little change!

What might we do to increase the efficiency of learning? What new ideas and methods are already here that might increase the student's learning efficiency? Here I am referring to both the quantity and the quality of the learning process. The S. R. I Report* lists some of the trends in education as compiled by Harol B. Gores, President of the Educational Facilities Laboratories. These trends are for public school education but certainly are als pertinent to junior colleges. These changes affect every facet of education: physical facilities, teachers, students, but most pronouncedly a different <u>attitude</u> towards teaching.

We who are teaching science in junior colleges have an excellent opportunity to incorporate many new ideas into our build ing programs, since the junior college movement has now begun to grow so rapidly throughout the nation. Here is indeed a challenge to our imagination, ideas, foresight, and courage. Let us hope that we build structures that are new educationally, and not based on obsolete college classroom and laboratory design that many arch tects seem to continue to build. Another challenge facing us is t courage to work unswervingly and with faith on newer concepts of teaching, at the guaranteed risk of being called a "faddist" by colleagues and something much worse by the general public--at the risk of failure.

Let us set an example to our fellow teachers by being extremely cautious against closing our minds to new and different approaches and assist wherever we can to give these infant ideas a fair chance for survival and testing. There never was a process or idea that could not be improved. Certainly, educational research is bound to lead to improvements.

I have a strong feeling that our friends and the general public will judge the junior college movement by the quality of our instruction and by our genuine concern for the individual student. We will win no brass medals for our excellence in scientif

*Stanford Research Institute, Menlo Park, California

search; nevertheless, we must pursue a vigorous program of edu-
tional research--and will be expected to do so--or fade into
e background of mediocrity and, so, disappoint the public who
pected much from us.

Turning now to more immediate problems, we have the task
educating the transfer student for two years in the junior
llege and essentially completing the training of the two-year
chnician. The transfer student is really the simpler problem.
a large extent, we are tied to the four-year colleges because
the need to coordinate our curricula with theirs. However,
nsidering chemistry and physics, I am somewhat concerned about
e trend to give all high school students the CHEM Study, CBA,
PSSC approaches. The high schools may be neglecting some of
e basic, so-called descriptive matter too soon in their eager-
ss to teach principles. In my day, every young, aspiring chem-
t had the opportunity to play with a Chemcraft chemistry set,
well as carry out experiments on making H_2, O_2, Cl_2, acetylene,
d a lot of other materials (including black gunpowder) that
uths today merely read about and seldom get to see, taste, smell,
d feel. Too early, an introduction into principles has the ef-
ct of learning <u>about</u> a highly abstract science. I would much
efer a first exposure to chemistry to be qualitative and highly
scriptive. College chemistry could then stress principles,
ich certainly must be taught. But my objection is to principles
<u>ly</u> without having first "tasted" chemistry.

I have organized my chemistry course for science majors
ely on principles, bringing in descriptive work whenever pos-
ble; nevertheless, the tacit understanding is that the student
s been earlier exposed to having "tasted" chemistry. We are
is year for the first time experimenting with a terminal chem-
ry course for nonscience majors that attempts to educate the
dent to understand current problems of society involving chem-
ry, e.g., air and water pollution, radioactive fallout, food
l fertilizer problems, and the like. I hope that our course
l make our graduates much better informed citizens and more
e to contribute constructively toward solving these pressing
sues.

Scientists are frequently criticized--and I believe right-
ly--for not taking more active part in society's problems. Here
another challenge we can grapple with! Do we teach only "prin-
les" with a complete disregard of the despoliation of our earth
atmosphere, allowing our students to be educated by TV adver-
ing and by publications of vested interests?

Finally, let's look at the two-year technology courses.
e we really do get into a mare's nest! Let me repeat: My com-
ts will be pertinent to the field in which I have spent my en-
e career--chemistry and chemical engineering. Thirty-five to
ty years ago attending a college was, for the most part, a
ction of wealth in the family. Essentially all who had the
essary financial assistance were able to attend one school or
er. Those with limited resources might attend a two-year col-
e to become a technologist. This permitted many very able

students--albeit poor--to get a start in the industry. Then came the tremendous growth of the Land-Grant Colleges, especially in the Middle West. This opened doors of opportunity to many more students. Again, however, standards were not too vigorous and usually there were more engineers available than job opportunities Perusal of statistics will show a large number of trained chemists and engineers who became disenchanted with the lack of jobs or the menial nature of their work, and so changed their field of activit

Thus, as a result of wider educational opportunities--particularly as compared to the European countries, an ample suppl of engineers was generated by the standard four-year colleges. Some of these engineers were very well trained; others, less so. On the job, natural selection soon took place, resulting in some engineers doing technicians' or technologists' work. With an ample supply of graduates in science and engineering, U. S. industry was oriented to use these graduates, with only a poor understanding of what the two-year technologist was or what his contribution could be. As a result, up to the present there has been an amazingly slow growth in full-time enrollments in technical institutes as compared to total college enrollments over the same years. To this day, there is still a severe lack of understanding on the part of industry of what a two-year technologist might do for them, primarily because industry is concerned about their long-term potential and their impact on labor unions.

Government statistics have in the past, and again more recently, stated that "the already short supply of engineers will be intensified in the near future." Many professional engineering societies will dispute this claim. I wonder if one factor has not been overlooked in the government statistics, i.e., the trend to further education of graduate working engineers which, of course, is a method of increasing their efficiency. There is much that ca be done along these lines, and I am most pleased to see the chemical industry in St. Louis working hand-in-glove with local universities and colleges to help upgrade their employees. Moves in this direction will curtail the predicted shortage of engineers.

Government statistics also, I suspect, are based on the need for technicians, assuming some arbitrary ratio of from two t four technicians per engineer. I would like to note that such a ratio has never been attained in the United States and would require a considerable difference in attitude on the part of indust especially since we now have about one technician per every two engineers.

The challenge in the technician area is to sort out <u>with industry</u> exactly what an engineer is, what his training should be and what a technologist is and what his education should be. We must be careful that we don't tool-up to produce a product that will not be bought by industry.

I strongly urge that we educate these engineering technology and industrial technology students, recognizing that they are likely to be in the 50th to the 20th percentile on the School and College Aptitude Test (SCAT), along the same lines as we do

our-year engineering students, only at a lower level--a level here these students can achieve success. There should be a pectrum of engineering abilities from the PhD down to the tech-ologist or technician, but not a basic difference in their edu-ation. Because the technologist cannot do differential equations oes not mean we teach him how to operate a "black box" to do nalytical or production control work. Industry can do this much etter than we can; furthermore, we are apt to be teaching the tudent how to use "black box 1" when the science has progressed o that industry is working on "black box 3." If it is true that n the future we will need to change the nature of our jobs about hree to five times during a career, all the more reason to edu-ate the two-year technologist along general lines stressing prin-iples on which he can continue to build. Again, job-oriented ngineering education in colleges and institutes is meaningless nd an economic waste!

Concluding, we in junior college science teaching must et ready to meet the challenge of the 1970-1980's by:

Learning how best to educate vast numbers of students of widely differing backgrounds; especially to find meaningful ways to help the less gifted student achieve his maximum potential.

Since we will not be judged by our scientific research but rather by the skill and excellence of our teaching, we must continually look for new ideas in education and keep an open-mindedness toward testing and using any procedures that have promise toward increasing the efficiency of learning. We shall need to do educational research.

We need to work more closely with industry and the scientific and engineering societies to develop a meaningful course of study for the less gifted but scientifically oriented student in our two-year technology programs.

Finally, we cannot much longer look at education as a means of making individuals more efficient in the art of production. We are forced to become concerned with making all individuals broadly educated persons, each to his maximum potential.

MEETING THE CHALLENGE II

Robert J. Hannelly
President
Maricopa County (Arizona) Junior College District

First and foremost, I should like to go on record to say that the junior college science teachers in Arizona are doing a creditable job.

As I considered the subject assigned to me, i.e., "Meeting the Challenge," I concluded that I must pluralize it into "Meeting the Challenges." Furthermore, I deem it necessary to recognize or state what the challenges are before making suggestions as to how to meet them.

Science teaching cannot escape the general challenges to all educational endeavor. Among these general challenges are the knowledge and population explosions. Challenges more germane to science teaching in the junior college are: traditional methods, the need for all citizens to know more about science, the exceptionally good science teaching in some high schools, and the maintenance of quality with quantity.

Let us first consider the knowledge explosion. There is now available a plethora of textbooks, periodicals, paperbacks, films, and canned knowledge. The $195 billion knowledge industry is growing twice as fast as the economy. The production of knowledge doubles every ten years, and there is 100 times as much to know as in 1900. By the year A.D. 2000, there will be more than 1000 times as much knowledge of all kinds to record, to sift, to store, to teach, and, hopefully, to use.

Technological knowledge is exploding also. There are 100 times as many chemists as in 1900. Ninety percent of all the scientists that ever lived are alive today. Dr. Norman Harris states that there are about 100 titles of jobs and professions in the medical field. More than 780 periodicals are published. An IBM ring of ten data cells can store 400,000,000 items, any one of which can be retrieved in a fraction of a second. Sophisticated hardware such as the F5, the IBM 360, and Gemini VI require new knowledge and vocabulary.

No less dramatic is the population explosion. In 1900, 4 percent of the college age youth attended college. Now it is 30 percent. In 1900, 6 percent of the nation's 17-year-olds graduated from high school. Now the figure is 71 percent.

President Lee A. DuBridge, of the California Institute of Technology, says "We are in deep trouble." But he adds, it is not the fault of the schools. He says further, "We are expecting too much of our schools and too fast."

Higher education in the United States will add more students in the next five years than were enrolled in 1954. The average size of colleges increased 55 percent between 1953 and 1960 and

ill increase another 50 percent in the next five years.

Meeting the challenges of the knowledge and population xplosions is not the sole responsibility of the junior college cience teachers, but it does complicate their problems. The whole ation, including the rank and file of the citizenry, must accept hese great challenges.

Now, I should like to proceed to matters for which science eachers may be able to accept more responsibility. Take tradition, or example. To particularize, take traditional method and content n science. Bold innovations have already been made, but has enough een done to select the most significant concepts, facts, and experi- ents to be taught or performed? What scientific knowledge is of ost worth? Next week's scientific discovery may make last week's extbook obsolete.

What is the best method to teach physics, chemistry, or iology? Is it in fact lecture and laboratory? If so, is the atio of half and half sound? To what extent should we use closed- ircuit television or programed materials? How can we individualize nstruction when there are so many students? It may be true that he science teachers are so busy that they do not have the time to nvestigate these questions and others for which they would like to now the answers.

Science teachers need help in research. Educational anal- sis by non-college agencies is gaining in volume and acceptance.

There is a serious omission when we speak only of improv- g content and method in the teaching of junior college science. t is the student. Too long we have ignored research about him. or example, how does he learn? How can he be motivated? Does he ave to have a certain minimum IQ in order to learn college science? e have no substantial research on human characteristics of the unior college student. Sporadic studies have been made. When I eard that Leland Medsker was making a full-scale investigation of his matter at Berkeley, I wrote for a copy of his findings. He aid it wasn't ready yet, and that was two years ago.

In order to meet the challenge of tradition, science teach- s in the community junior college can insist that scientific anal- sis be applied to the problems in content, method, and student haracteristics. This emphasis should come easily to the chief ex- sitors and promulgators of the scientific method on the junior ollege faculties.

Next, let us discuss briefly the tremendous need for the erage citizen to acquire more scientific knowledge for life in e future. Here again, we may be referring to a national problem. rmer Commissioner of Education, Francis Keppel, has said, "Edu- tion is too important to be left solely to educators."

Yesterday's education no longer suffices for tomorrow's ills. Secretary of Labor Wirtz points out that the machine now s a high school education in the sense that it can do most of

the jobs a high school graduate can do. So the machine will get the jobs, because it works for a lower wage. A junior college education is necessary to compete with the machine.

For the sake of simplicity, let us divide junior college students into three categories: the upper 25 percent who go into professions, managerial, or high-level service jobs; the middle 50 percent or the average student; and the lowest 25 percent, the less able students. The top 25 percent includes students who will become physicians, dentists, engineers, and science teachers. All of these will be well grounded in science. Learning science is relatively easy for them. But also included in the top 25 percent are the students who become lawyers, managers, business executives, and English teachers. To what extent are we providing the science education that all of these will certainly need to function intelligently in the next generation?

Now, let us comment about the lowest 25 percent of the students. Learning science is difficult for them. Certainly, the standard courses in chemistry, physics, biology, and mathematics are generally beyond their comprehension. Still, there is a linger ing question as to whether we owe to them the opportunity for them to try to learn some simplified, basic fundamentals in science. They are much above the average of the general population. They will vote, conduct business, and support the community in the futur

Now we come to the $64 question. What should we do for th middle 50 percent of the students? They will constitute the warp and the woof of our society. Are the courses we now give suited tc their abilities and future needs? After taking our regulation courses in science, could these students write a coherent page on "What is atomic fission?" or "How does solid fuel give power?" or What really is soda water?" or "Exactly what happens when water freezes into ice?"

Is general science the answer? Should there be several levels and kinds of courses for this large group? Most of them will never enter scientific occupations. Here we are talking about the average college students. These are good and substantial peopl Furthermore, there are many of them.

What kind of a science program does the college and the community, state, and nation it represents owe to these substantial citizens? In my view it owes its best effort, research, and instructional standards. They are capable of learning a great deal of science, and they will need it.

There is another serious problem about the middle 50 percent category, and that is "Which requirements should the college set up for them?" They can't learn science in college if they avoid it. I would hope that the future program for this group would be so attractive that students would be eager to participate in it. I believe it can be so constructed and offered.

Now just a final word about meeting the challenge in junior college science teaching: We can question the obvious and

traditional in content, method, and student characteristics. We can experiment with these variables or insist that experimentation should be performed. We can exert every effort to make sure that the middle 50 percent has a required, solid program of quality. We can accelerate brilliant high school students. Last, but not least, we can continue to expand our own scientific knowledge and teaching techniques by formal and informal study.

MANPOWER, MONEY, AND MOLECULES

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Biology education today is influenced by important changes in three areas--manpower, money, and molecules. I am referring to (1) the supply, training, and functioning of teachers, (2) the influx of money for improving teaching, for research, and for support of students, and (3) the influence of the vast expansion of our knowledge of molecular mechanisms in life processes.

The Teacher

A great deal can be said about recent improvements in textbooks, laboratory experiments, teaching aids such as films and television, curricula and the like; but all of these depend for their success on the teacher. The quality of teaching is determined ultimately, not by the paraphernalia, but by the personal qualities of the teacher. He must first know his subject, but he must also be aware that he exemplifies intellectual virtues and very often moral values and personal tastes.

The general awareness of this truism has led to more rigorous training and greater selectivity for teaching in biology and to more numerous opportunities for additional training and upgrading. I consider research participation to be an important activity in this category; teachers concerned primarily with undergraduate education should be given every opportunity to participate in research projects.

The Resources

Research projects, summer and academic year institutes, experimental courses and programs require money. Apparently this money will be forthcoming through expanded federal programs, including the Higher Education Act. Vast sums for education will be spent in the next five years unwisely unless we make our needs known. Students will benefit not only from the added resources for the institutions, but also from increased availability of financial aids. Another GI bill will probably be passed to add to this subsidy.

The New Biology

The third trend which has generated so many new approaches in biology education is the molecular revolution. The whole area of molecular biology is either deified or denigrated more often than it is put in its proper perspective. Spectacular breakthroughs in our understanding of a number of very crucial life processes have come from the application of the techniques and theories of the physical sciences to biology, but it is the achievements, not the applications of physical methods and principles that are new. When modern chemistry was brand new, 150 years ago, it was being applied to biological problems. The climate in the life sciences in the

ast 20 years has been ripe for a new synthesis, back from an edu-
ational, administrative, and investigational fragmentation that
ad taken place over the years. The molecular trend required this
tmosphere for its success and served in turn to reinforce the move-
ent toward the reductive, integrative, comparative approaches that
ere already there. There has been a counter-trend, however, that
as sometimes masked the increased unity in the life sciences. New
ields of specialization, which tend to foster narrowness of train-
ng and outlook, continue to develop.

he New Curricula

The increased unity within the life sciences has forced
he educational system toward a more unified approach to under-
raduate education. The classic division between botany and zoology
as been broken down at the elementary level, and introductory
ourses now include important elements from microbiology, biochem-
stry, physiology, ecology, genetics, and other older and newer ad-
inistrative and research divisions. A life sciences major now fre-
uently requires a core curriculum of physical sciences, mathematics,
nd courses in various departments of the life sciences area before
omplete submergence in one specialty is permitted. If a junior
ollege student intends to transfer to a senior institution, he
ould be aware of these requirements.

ne Teacher's Dilemma

The added breadth in curricula creates a problem in the
aining of those who are to become teachers at the undergraduate
vel. If the teacher has been trained in one specialty, for ex-
ple marine ecology, he may have little or no knowledge of another
dely divergent specialty in the life sciences, for example bio-
emical genetics. There would be some question as to this instruc-
r's ability or desire to present a balanced elementary course.

The molecular preoccupation has created the severest prob-
ms in biology education. Lack of teacher preparation in the
ysical sciences leads, in some cases, to abandonment of any at-
mpt to present molecular information; or an attempt is made that
overambitious, unclear, or just plain wrong. On the other hand,
ere has been a tendency for those with a strong molecular orien-
tion to cover inadequately the higher levels of organization--the
ll, organism, and population--and higher functional areas such as
havior.

Research participation, summer institutes, and released
ne for study are ways for the teacher to increase his versatility,
l they should be encouraged and supported. But there is just so
ch that a normal person can accomplish. One way out of this is
rough team teaching, but this has some well-known drawbacks. It
ould, nevertheless, receive more thought, experimentation, and
pport than it usually gets. One of the reasons for the need for
am teaching is the trend to even broader interdisciplinary pro-
ams, which require the coordination of teaching over very wide
ject areas.

The Basket Approach

With the interdisciplinary trend well advanced within the life sciences, some institutions are now covering all of the introductory science courses in one comprehensive, integrated sequence required of both majors and non-majors. These programs often follow a conventional basic format using blocks of subject matter from mathematics and the physical sciences before commencing the life sciences. A topic can be presented outside of its usual setting at a point that emphasizes its further application and its broader implications. This makes a great deal of sense to the student who will more willingly follow a sequence dictated by the subject matter rather than an arbitrary, overlapping, or disjointed sequence dictated by the usual departmental and administrative concerns. These courses have received support from those concerned with education in the sciences for the non-science major because the complete program would prevent a student from entirely avoiding major areas in the sciences. The molecular biologists like the courses because every student in the biology sequence has received a controlled prior exposure to the physical sciences.

Core programs and courses are not new in education; they have been tried many times and frequently have failed. The biggest single barrier to success in these programs is in finding the professional and institutional setting that will permit them to function over extended periods. Teachers with attitudes and background that properly mesh can be found to teach the courses, provided thei respective departments can release the time and not penalize the participant for efforts outside his immediate specialty. The cours should be a more efficient route to basic education than the normal relatively uncoordinated program based on a set of academic regulations and half-hearted, even conflicting, advice.

A serious problem for interdisciplinary courses is coordir ation. The secret to success is good organization and a good coordinator. This generally means time: A great deal of the coordir ator's time is needed for design, meetings with lecturers and labor atory instructors, and for previewing of curricular materials. It is here that some critical support can come from granting agencies: for released time to enable schools to design, staff, and implement interdisciplinary programs.

Summary

I have tried here to emphasize that a common thread in many specific new approaches in biology education has been a trend toward implementing in educational practice the unity which has taken hold within the existing theory and techniques in the life sciences. This trend should continue, aided by support from the federal government.

NEW APPROACHES IN THE PHYSICAL SCIENCES IN THE TWO-YEAR COLLEGES

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The most significant new approach related to teaching sci-nce in the California junior colleges is the faculty realization hat our colleges are open-door, comprehensive, and community in ature. Faculties and administrations are looking anew at courses nd curricula to see whether they reflect the education-in-science eeds of student bodies characterized by diverse goals, backgrounds, nd abilities.

Traditionally, the science faculty of public junior col-eges have looked to the major universities and state colleges as he source of all knowledge and wisdom in curricular matters and hen, influenced by the pragmatic demands of the local college dministrators, they have established courses in chemistry and hysics much like those at the four-year institutions. Today, ressures for change are causing a re-examination of these patterns nd a searching elsewhere for new goals and plans for curriculum evelopment. Fortunately, new sources have been found, and some ew channels of communication have been established. Before con-idering these pressures and sources, we should look at the open-oor, comprehensive, community college characterization more closely.

The term "open-door" means that entry into college is un-estricted. Many courses and curricula are available--some within he range of the student's interests and ability, some outside his nterests, and some beyond his ability. He need not choose what ies outside his interest, and he should not be allowed to choose hat which clearly lies beyond his ability. The open-door college oes not mean an open-door curriculum. It presupposes a variety f curricula to match the potential of a variety of students and he establishment of standards to maintain the integrity of the nstitution.

The term "comprehensive" means a multiplicity of educa-ional functions or purposes. Junior colleges generally subscribe o five: (1) education for transfer to four-year colleges and niversities, (2) education for occupational competence, (3) gen-al education, (4) guidance, and (5) community service.

The "community" concept arises because a college is lo-ally governed, receives the majority of its financial support rom local sources, is tuition free, and responds quickly to the ducational needs of the community. With an extended day sched-ing of classes, the evening enrollment may be larger than the day.

There are six trends or changes which are forcing recon-ideration of the structure and content of the chemistry and physics ourse offerings of the two-year colleges. These are:

The enrollment of a wider variety of students, with diverse

goals, abilities, and backgrounds in our colleges.

2. The better preparation of more freshman students in science and mathematics than previously was the case.

3. The changing nature of the chemistry and physics in lower division science, engineering, and preprofessional courses to prepare students for upper level undergraduate or professional school work. This is forcefully seen by recent curricular changes in four-year colleges and by new textual materials that are being prepared and published.

4. The requirement of industrial and research activities for an increased number of technician-level personnel to assist the professional person in research and development and in production and control.

5. The flood of new information and the many different ways in which this new information is being worked into the college curriculum.

6. The development of modern equipment, making available challenging new experiments and new methods of presentation.

The second significant new approach is the recognition that many two-year college faculty members are outstanding chemistry educators or physics educators and that they are reputable chemists and physicists. This permits faculty members to make contributions and participate in chemistry and physics education activities more than ever before. This recognition has been instrumental in the development of programs for junior college faculty in the various science disciplines. When faculty members from the five types of two-year colleges, the public junior college, the community college, the private junior college, the technical institute, and the two-year center of the university meet to share ideas, experiences, problems, programs, and successes, much is gained.

One such program is now being conducted on a national and regional basis in chemistry. The Two-Year College Chemistry Conference of the Division of Chemical Education, American Chemical Society, brings to the attention of the chemical community and profession the faculty, students, programs, and problems of the two-year colleges. It allows the faculty members from different states and types of colleges to get together to discuss their problems, without domination by the four-year college people. It encourages two-year college chemistry faculty members to get into the mainstream of action and new communication between the junior college faculty member and organizations and foundations interested in the chemistry programs and faculties of the two-year colleges such as the Manufacturing Chemists' Association, the National Science Foundation, the Advisory Council on College Chemistry, and the National Science Teachers Association. The chemists encourage other disciplines to do the same.

I should now like to turn to the consideration of several

pecific newer approaches to the teaching of chemistry and physics n our colleges. These approaches involve new courses, new standrds for courses, new course content, new laboratory approaches, ew curricula, new text materials, and the utilization of some of he newer developments in educational media. I shall try to relate hese newer approaches to the five educational functions and the ix pressures mentioned earlier. It is not possible, in this short ime, to cover the many new approaches existent today, so I have ndeavored to select examples which are both significant and repreentative.

ducation for Transfer

Several examples are related to the education for transfer unction which includes providing a well-rounded lower division ducation for persons who desire to continue their collegiate eduation beyond two years. Because many students cannot qualify for dmission to the university or state college upon high school gradation, but are capable of obtaining the bachelor's degree, we must rovide an opportunity for them to demonstrate their capacity to aintain, over an extended period, an acceptable standard of scholrship in subjects of collegiate level, so that they can enter the our-year institution as fully qualified juniors. Many such stuents, who are initially ineligible for admission, transfer to and raduate from the four-year college, and continue on to graduate ork and higher degrees.

The general chemistry area offers an excellent example of ew approaches because there are several associated with this proram. First, the changing nature of the course content and better reparation of the freshman students have caused a strengthening of he prerequisites for the course. Students in many colleges now ust have a previous course in chemistry with a good grade and have ompleted three or more years of high school mathematics or equivaent and validate this background on a placement examination.

Second, because of the wide variety of students' abilities nd backgrounds, junior colleges are establishing beginning or eleentary courses in chemistry to provide the student the opportunity o prepare himself for the general chemistry course. In earlier ears and smaller colleges, this was done by having these students nroll in the non-science course. Today, the diversity of student oals and abilities and mathematical backgrounds is so great that he groups have been separated into two courses.

The new content in general chemistry, which was first inroduced several years ago, involves a continuation of the shift rom a descriptive, inorganic course to a principles course conerned with topics formerly considered in physical chemistry ourses. There is greater concern with the relationship between he structure of a substance or particle and the properties of he substance and with the investigation of chemical systems in rms of the thermodynamic and kinetic characteristics. Structures nd systems are increasingly being viewed in terms of quantum oncepts.

The general chemistry laboratory is being changed. It is moving rapidly toward quantitative experiments demanding student performance that is up to professional standards, with greater emphasis on technique and comprehension, but with a smaller number of experiments being required. Instruments being included in the general chemistry program include the analytical balance, pH meters, spectrophotometers, and chromatographs. There are two distinctive approaches identifiable among junior colleges as they make their general chemistry laboratory more quantitative. One approach introduces the experimental work traditionally found in quantitative analysis into general chemistry. The second investigates chemical systems by making accurate measurements of various physico-chemical properties of the system. The increased use of experiments utilizing unknown samples or requiring answers which are unknown to the student is characteristic of both approaches.

A new approach appearing on the horizon is the development of two courses in general chemistry for science and engineering and closely related majors. There will probably be two different approaches to the differentiation of these courses. One will involve the honors course and regular course approach, while the other will set up one course for physical and biological science majors and some engineers and another for the other students.

The physicists are not being left out of this change. Junior colleges are adopting new approaches to their physics for physical science and engineering majors. These new approaches are being influenced by the better preparation of students, the changes in the mathematics curriculum, and the changing nature of the textual materials being produced for courses such as those at Cal Tech, M.I.T., University of California at Berkeley, and others. These new approaches place more emphasis on the fundamental concepts which form the foundations of contemporary, quantum phenomena, waves and oscillations, and statistical physics, in addition to mechanics, electricity, and thermal physics.

These approaches attempt to convey to the student some of the interest and excitement which the physicist finds in his subject. They stress an understanding of the subject matter in terms of physical and chemical concepts as well as the mathematical analysis. They make strong ties to observable physical and chemical phenomena and they make extensive use of various model forms, to develop an understanding of the concepts in terms of the observed phenomena.

The laboratory involves the use of apparatus capable of making accurate measurements, the introduction of error analysis and statistical experiments, and the imaginative exploration of physical phenomena using electronic equipment. There is some indication that such courses will demand more lecture time and five quarters or four semesters as the minimum, although some of the four-year schools adopting but not developing these approaches, are unwilling to give that much time.

Education for Occupational Competence

Perhaps the most dramatic new approaches are found within the scope of the education for occupational competence function.

his includes providing programs which qualify students for em-
loyment in an occupation after two years of college, and in pro-
rams for workers to upgrade their skills or employment qualifica-
ions or to prepare for another category of employment. These
urricula lead to the associate degree and/or a certificate of
echnological competence after two years of full-time study.

The introduction of completely new curricula is the first
hange which we should mention. Curricula with which the chemistry
d physics departments are most directly concerned are those which
rain semi-professional technicians for research and design activ-
ties in support of engineers and scientists. Some manual skills
e required, but the major emphasis is on technical knowledge.
ny industrial research facilities wish to train technicians in
e more specific skills required by the work of their company.
ese curricula include a balance between the engineering or sci-
ce and the technician aspect of the program. Technician programs
ich almost parallel lower division engineering or science curric-
a result in high attrition rates, too few graduating technicians
d general dissatisfaction with the community college's technical
ucation program. When industry wants people for industrial re-
arch positions with the type of background found in the transfer
ogram, they hire students from such programs rather than from a
chnician program.

The semi-professional technician programs generally re-
ire one year of technical physics with laboratory, and may or
y not require chemistry, depending on the importance of chemis-
y in the technology. Many colleges are now establishing separate
chnical physics courses, different from the premedical type gen-
al physics, and separate technical chemistry courses, different
om the non-science major and general courses.

I would like to discuss the new chemical technology curric-
a for a moment, because there are two distinctive approaches emerg-
g here. The first approach generally has the student in chemical
chnology enroll in the same general chemistry, organic chemistry,
d quantitative analysis courses as the transfer student, but dif-
rentiates from the transfer program in the physics and mathematics
quired. They also include courses in other technologies and in-
rumental methods of analysis, and possible industrial chemistry
unit operations. They do not include languages. This is gener-
ly established where industry wants the students to be able to
on to obtain the baccalaureate degree.

The second approach is the establishment of a curriculum
chemical technology emphasizing the training of career techni-
ans. Students who could be expected to obtain a bachelor's de-
ee are not encouraged to enroll in chemical technology. Instead,
udents are sought who show determination, who enjoy laboratory
rk, whose chances of obtaining the bachelor's degree are slight,
d who are willing to make work as a technician in the chemical
boratory their career. Science and engineering students who are
able in the laboratory but who cannot handle the rigor and theory
the transfer chemistry, physics, and mathematics courses may
ansfer to the chemical technology programs.

The chemical technology curriculum includes separate courses in the fields of general chemistry, organic chemistry, analytical chemistry, instrumental methods, industrial analysis, industrial chemistry, introduction to chemical technology, and unit operations. These courses emphasize laboratory work and are taught by members of the chemistry faculty with experience in training and using technicians to assist them in research work in industry. Students are provided with precise directions in great detail for operation of instruments used in experiments.

Another trend involving chemistry and physics and occupational curricula is the establishment of some courses for specific curricula such as nursing, dental assisting, fire science, electronic technology, and the like.

General Education

Education to develop competence as an individual, as a citizen, and as an effective community leader is included in the general education function. Most junior colleges in California now have at least one such course in chemistry and one in physics.

It is generally accepted that every good chemistry, physic and physical science course must have over-all unity and coherence. Without structure and pattern to hold it together, a course may be difficult to learn and easy to forget and may contribute little to the understanding or appreciation of chemistry or physics. Many of our present courses, especially for the non-science major, can be indicted on two major counts: (1) They deal with many unimportant topics, and (2) they are often a fragmented series of pieces held together only by the glue on the spine of the textbook. One of the most significant new approaches in both the courses for science majors and the non-science majors is the use of themes as the central organizing thread throughout a given course. Such a theme can permit a wide variety of materials to be introduced, all of which can be related to the theme. Examples of such themes in chemistry courses have been chemical systems and chemical bonding and structure. Examples in physics include energy, matter and energy, symmetry, and model making.

A recent Conference on Physics for the Non-Science Major was reported in Newsletter Number 7 of the Commission on College Physics. The reporter spoke thusly regarding the conference view of these courses:

> "The single channel, antiseptic, analytical, logical, coldly beautiful, traditional pattern of teaching introductory physics does not communicate to the non-science oriented students. The traditional approach is probably highly efficient for the typical physics major--he furnishes his own internal motivation, and he tends to be happy with and to feel at home with the analytical, mathematical approach. The tendency in the past--happily on its way out--was to simply dilute this hard-boiled physics down to a concentration at which it could just barely be

> swallowed by the non-physics science major without rebelling and plough ahead. The conference group was composed almost entirely of people who feel that this approach is no longer adequate . . .
>
> "The most salient feature, by far, of this group of students is the tremendous range of intellectual types. I don't mean IQ. They may all be reasonably smart. But some are verbal, some think abstractly, some can visualize, some could put a carburetor together, some can solve a differential equation but can't say whether a ball will go up or down if you let it loose."

There are three additional topics related to new approaches the physical sciences which should be mentioned. These are (1) ilization of the new textual materials, (2) utilization of some of e new educational media, and (3) research by students and faculty.

Two-year college faculty use the various new textual marials in three ways:

As a primary test with other more conventional texts referred to as sources of questions and problem examples (Students in such situations may tend to become enthusiastic about these new materials since they feel they really learn physics or chemistry from them.)

As enrichment for an otherwise conventional course (Students may gain new insights in the classical physics or chemistry and satisfy their curiosity about relativity or topics in contemporary physics by this approach.)

Instructors may use the new books for preparing lectures in their otherwise conventional courses (Students in this case will not come into direct contact with new textual materials.)

A recent Newsletter of the Commission on College Physics, mber 8, calls attention to the importance of keeping in mind that e new materials in existence in physics appear at present to be tants representing an entirely new breed of physics texts, vigors and exciting, though not yet completely adapted to the environnt of the physics courses for which they were intended.

We must realize that the new textual and subject-matter forts often lack many of the ancillary teaching aids required for rmonious accommodation to the classroom. These aids may include oblems of graded difficulty, solved examples, thought-provoking estions, directions for demonstrations or lecture experiments, l laboratory experiments, but teachers wishing to adapt or adopt ese new materials may find it necessary to provide tender and ne-consuming care during the period of development. In fact it hoped that many individuals, through using these materials with-t the appropriate aids, will be stimulated to develop such aids.

The maturation process for the new approaches will be comete only when individuals or groups of chemists or physicists ve grafted on to the new materials appropriate teaching aids and

media, because these are essential to the new approaches and because their own understanding and background are not as steeped in the tradition of the new as in the tradition of the old.

The techniques and media which seem appropriate to these new developments and approaches in the physical sciences include the traditional 16 mm motion picture, the 8 mm motion picture including the cartridge forms which fit the Fairchild and Technicolor projectors, video tape, the carousel console in which an audio type is synchronized with 35 mm slides or motion pictures, programed instructional materials, models, and audio tape. We will see a coordinated development of instructional materials using many of these different techniques appearing in the next few years.

Research

How is research one of the significant new approaches? Consider for a definition of research that of the Wooster Conference on Teaching and Research in Chemistry in the Liberal Arts College,"Research is the application of creative thinking to the solution of any problem." In the November 1964 Junior College Journal, John E. Anderson, President of Columbus College in Georgia, has written an article entitled, "Research in the Junior College--An Anathema or Anodyne?" in which he sets forth the hypothesis that an administrator who discourages research is forfeiting a curative for some chronic problems. Anderson believes that administrators are committing two major errors if they say, "We are interested in teachers, not researchers." The same errors are made by those who actively discourage any research tendencies found in their faculty members and exhort them to spend their time in becoming better teachers; or those who hold the suspicion that the two concepts of research and teaching, if not mutually exclusive, are at least incompatible drives within the same individual. First, he says, they are exhibiting a fundamental misunderstanding of research and, secondly, they are doing a disservice to their institution and ultimately to the taxpayers who support it.

Those pressing problems found in every college can be solved best by the very process that is research, which at first seems a waste of time. In the final analysis, Anderson says, "Research be it pure or applied is really a problem-oriented spirit of inquiry, channeled and directed by a rigorous methodology. Through research problems can be definitely stated, relevant data gathered, and meaningful results obtained. This is certainly what the administrator needs as he attempts to respond to the problems besetting him."

The error of doing a disservice to the institution and ultimately to the taxpayers revolves around three foci--students, faculty, and the college. Anderson points out that at the undergraduate level in the four-year college, the spirit of inquiry is fostered in the students. The instructor often acts as a repository of that specific research methodology which is best suited for the particular project under investigation. He notes that humanities, sciences, or business courses emphasize the reading of current professional literature with the attendant language of mathematics

nd statistics. To educate a student in a junior college atmos-
here which is foreign, not to say hostile, to research consider-
tions and to expose him to instruction and instructors who are
ot familiar with or engaging in research is to do him a grave
njustice, not only in terms of difficulty of transition to the
enior institution environment but also in terms of the self-
atisfaction and growth inherent in the completion of research
rojects.

Administrators contribute an additional difficulty in re-
ruitment of faculty when they deprive the instructor of the op-
ortunity to do creative research. Likewise, the complaint heard
rom junior college instructors is that the world is passing them
y, and their knowledge and subject matter are outdated. This is
specially true of science instructors who, perhaps not permitted
o do research during the year, are exhorted to return to school
r workshops during the summers to keep abreast of their fields.
t is a curious inconsistency for administrators to prate against
esearch for nine months and preach for it the other three.

Anderson feels that research will enhance the reputation
nd esteem of a junior college as an educational institution. The
stablishment of an atmosphere wherein the faculty contributes pro-
ortionately to professional literature, brings outside grant money
nto the community, and engages in community research and business
onsulting would provide the leadership which an institution of
igher learning should for a community.

In conclusion, I feel there are many new approaches to
he teaching of the physical sciences in the two-year colleges,
nd I have tried to identify some of the more significant ones.

and cytoplasmic convection. Ernest C. Pollard,[1] at the Pennsylvania State University, has concluded that gravity can account for a difference in the statistical distribution of intracellular particles when these particles get to be about 10 microns or larger in size. His calculations suggest that biological effects can be expected to occur at the level of the nucleolus, so that one could anticipate some changes in enzyme formation and organism development. To study the problem of weightlessness at the cellular level, one needs developing organisms with dimensions of the order of about a millimeter or greater.

Theoretical guidelines like these are valuable in the design of flight experiments. Major practical problems, however, have arisen related to the combined effects of the spacecraft environment. It has been difficult to control all elements of the spacecraft environment so that one can study weightlessness in the classic scientific manner. From the work of the Soviet Union, it appears that some of the cellular effects are related to more than one factor in the environment of space flight. Their data suggest that the combination of the launch acceleration and vibration with radiation and weightlessness may indeed induce changes at the cellular level. A great deal of laboratory work is being done at present to study these changes and to determine which ones are related to weightlessness. A remarkably large number of cellular species have been been flown in space, both by the United States and by the Soviet Union, but data interpretation is complex and very little has been established.

My interest in cellular changes related to zero g lies in a NASA-sponsored experiment which Donald Ekberg of my group, in association with Richard W. Price of Colorado State University, is performing which utilizes the amoeba Pelomyxa Carolenensis. It's a giant, averaging a millimeter in size. It has a hundred to a thousand nuclei and is extremely radiation-insensitive. To kill the animal requires the destruction of a large number of its nuclei; and its tolerance, therefore, is approximately 10^3 rad. It is planned to study the feeding behavior of the amoeba, its division rate (all the nuclei divide simultaneously) and to examine vacuole formation by electron microscopic and cytochemical methods. The experiment will be flown this fall on the NASA Biosatellite. Our laboratory work at present is primarily concerned with establishing the effects of vibration on the organism so that these effects can be separated from those of weightlessness.

Although the daily radiation dose at the altitude of the orbit to be used for this experiment are low (millirads), it is possible to select organisms that are sensitive to this level of radiation. The lysogenic bacteria (E. coli, K-12) are radiosensitive in the range of 200 to 400 millirads, and show alterations in induced phage production following exposure to the complex physical environment of space flight. Work is going forward to exploit organisms as radiation detectors, and the Soviets are actively concerned with their use in the study of radio-protective chemicals.

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[1] Pollard, Ernest C. "Theoretical Studies on Living Systems in the Absence of Mechanical Stress." Journal of Theoretical Biology, 8: 113-123, 1965.

BIOLOGICAL ASPECTS OF THE SPACE PROGRAM

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Space biology and medicine generally lie in the area of cology, the relationship of the organism to its environment. However, we should be careful to distinguish that in the space context t is the relationship of the organism to the spacecraft environent that is significant, not the relationship to the space environent itself. The engineering task is to tailor a device, the spaceraft and its enclosed environment, in such a way as to protect the rganism from the adverse effects of the space environment. Biological problems arise because the weight and power limitations of he spacecraft will not permit us to maintain terrestrial conditions.

Consequently, a great deal of work has been done on detering what kind of departures from the terrestrial environment the rganism can tolerate. Early in the manned space flight program, ffort was devoted primarily to such considerations as how much can an stand in the way of g forces and how can we compromise the atospheric composition and pressure in order to save weight. These re very practical problems, and human tolerance limits are fairly ell known for a whole host of such physiological variables.

There are some elements in the space environment, however, hat we cannot easily control without a considerable expenditure in eight, space, power, and money. This is the reason why weightlessess has loomed as one of the central problems in space biology. eightlessness can be controlled by rotation of the space station, ut this is an inordinately complex and expensive procedure. The adiation environment--its composition, how the vehicle wall changes he composition of the radiation, and what effects both the primary nd secondary radiation will have on the organism--requires additional study. There is much interest in the so-called circadian hythms (innate biological rhythms that fluctuate on a daily basis), ut we do not know yet their significance for astronaut functions. he astronauts put tinfoil over the windows and make their own 24our cycle so that they sleep just as though they were still at Cape ennedy. The effects of magnetic fields on biological organisms are ot well described. The magnetic field of the earth is approximatey 0.5 gauss, but both the moon and Mars have very low magnetic ields. Research on the biological effects of both high and extremey low magnetic fields is currently in progress.

eightlessness

The site of action of gravity on the biological organism as not been established, and space flight experiments to date have ot been really helpful in settling this question. There has been theoretical analysis to determine what this effect might be at he cellular level based upon the distribution of the components f the cell under the combined influence of Brownian motion, gravity,

At the mammalian level, the statement of the weightlessness problem has gradually evolved and has now taken the form of an inquiry into the gravity-dependence of body function. This is a relevant problem for terrestrial life as well as for orbital life. For years it had been taught that gravity is bad, that a man was really meant to be on all fours, and that the consequences of the erect posture are flat feet, pain in the back, and dropping of viscera. The ills that the orthopedic surgeon now takes care of were thought to be related to this awful thing, gravity. However, during the last war, it became apparent that lying down was an equal hazard; and we entered an era in which attention was focused on the problems of bed rest. A number of the complications following surgery or after delivery were shown to be related to recumbency and inactivity. Early ambulation of the surgical patient became common. Some of you may have experienced this treatment and have considered it extremely unpleasant. However, the result has been a remarkable decline in complications.

At the theoretical or experimental level, present work had to do with the effect of recumbency, the results of the attendant inactivity and the relation of these effects to weightlessness. It appears that these effects are very close to those that are anticipated in weightlessness. In weightlessness, of course, the gravitational force is absent, the hydrostatic force has disappeared from the cardiovascular system, and the musculo-skeletal system is unloaded. A certain amount of our daily energy is spent combatting gravity; in weightlessness, this is no longer necessary. In both the best-rest patient and during weightlessness the body adapts to its new physiological state. Many hundreds of normal people have been or are now lying in bed, primarily for the study of the problem of weightlessness and not for the purposes of clinical medicine. Researchers are trying to discover which systems of the body adapt; what is the time course of the adaptation; whether a new steady state is reached; and how one readapts an individual to gravity. In the normal individual the body undergoes changes that are entirely appropriate to the situation. The threat to the individual comes when he re-enters the gravitational field. Those of you who have been in bed for a long time know that if you stand up suddenly you may faint. The astronauts do not faint when they come back from space, but appropriate measurements show that everything is going in the direction of fainting; that is, on a tilt table after flight, men may feel the blood pressure falls, the heart rate is elevated, and the men feel dizzy.

Present research is directed toward the answers to the following questions: "Is it really true that the adaptation to weightlessness is appropriate?" If the adaptation is not appropriate, how can it be prevented?" If adaptation cannot be prevented, can the man be supported adequately on return to earth?"

The adaptations of interest in the cardiovascular system include changes in amount of circulating blood volume and in ability to mobilize reflex resources to prevent drastic falls in blood pressure on exposure to gravity. Adaptations in the musculo-skeletal system include the loss of calcium when the skeleton is unloaded. When the muscular system is unloaded, the muscles may undergo a disuse atrophy.

Investigators are concerned with the development of untermeasures for weightlessness. For instance, what kind and w much exercise should an individual be given to prevent the loss bone calcium muscular mass? With the Gemini capsule this is rticularly difficult because it is about the size of the front at of a Volkswagen, a pretty confining environment. Researchers e also studying a device called the lower body negative pressure rment. It permits the application of negative pressure around e lower part of the body to simulate the hydrostatic forces in e vascular system which would normally occur under 1 g.

It is extremely difficult to achieve true zero g for any ntinuous period in orbit and, consequently, one has to decide at to accept experimentally as a reasonable approximation for ological experiments. The NASA Biosatellite carries the specication that 90 percent of the time the g level will be 10^{-5} g, d 10 percent of the time it may be at 10^{-4} g. This specification dicates the precision with which one must hold the attitude of e spacecraft. Rotation of the spacecraft will generate acceleraon around its center of mass. If the specimen happens to be in e periphery of the vehicle, it may experience g's in excess of e specification. This kind of spacecraft stability is a real gineering challenge primarily dictated by a biological requirement.

crobiology

Microbiology is emerging as a specialty of considerable portance in space biology. Several areas have a significant imct on current and future space flight programs, in particular, e relation of microbiology to the closed environment of a space bin, the problem of sterilization of planetary spacecraft, and e detection of extraterrestrial life.

The relationship of microbiology to the spacecraft environnt in which man is placed is well illustrated by an experiment nducted by Reyniers[27] some years ago. He put normal rats in a aled environment, supplied sterile air, sterile water, and sterile od, and then observed what changes took place in the animal, parcularly the microflora of its intestinal tract, skin, nose, and roat. The following events took place: Over the course of the rst few weeks, the number of species of organisms, which are trendous in any living mammal, decreased in number, a process called mplification, so that at the end of a short time, instead of havg a profusion of organisms of all kinds, the species were reduced only a few known types. The system then became what is now calla gnotobiological system. All organisms that were present in the stem were known. The consequences of this process were several. e remaining species of organisms were found throughout the intesnal tract, a process known as flooding. In other words, the same ganisms would appear in the intestinal tract and in the nose and roat, where ordinarily different sorts of species survived.

Moreover, the animal may suffer a loss of immunity; that , as species disappear, the animal's immunity to these organisms

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Reyniers, J. A. Lobund Reports, University of Notre Dame Press, 1: 94-95, 1946.

may disappear as well. In certain cases the animal might become overwhelmed with a single species that had overgrown and outstripped all the others. If a specific antibiotic is given, it may be possible to produce a germ-free animal. In animals, loss of bacterial species may also result in altered nutrition. Bacteria in the intestinal tract fabricate certain vitamins. When these bacteria are lost, this vitamin symthesis process is also lost. When the animals were removed from the sealed environment and exposed to other animals in the colony, they acquired a new spectrum of organisms. The usual outcome was that the animal died.

The implications of this research are clear for the space cabin occupants. The source of oxygen in present manned spacecraft is cryogenic or liquid oxygen. In the future it might be acquired from the electrolysis of water. In any case, it is undoubtedly sterile. The water that is supplied to the crew may come from a combination of hydrogen and oxygen formed in a fuel cell, or, if the water is launched with the spacecraft, it is triply distilled. and the whole system is sterile. The food, as well, is very nearly sterile. Synthetic foods, such as Metrecal, are likely to be absolutely sterile. Freeze-dried foods prepared for space flight have an extraordinarily low bacterial count because of the nature of the processing and quality control required.

By analogy the space cabin is very much like the condition in Reynier's experiments and represents a complex problem in ecology. The problem is not academic, as indicated by a 30-day test performed recently at the Boeing Aircraft Company[3/] where many of these conditions pertained. In this manned test the organism of interest that emerged was Shigella, a fairly pathogenic organism. In other similar studies the subjects suffered nausea, diarrhea, and skin rashes, presumably related to this kind of bacteriological problem.

The microbiologist has an important role to play in the sterilization of planetary spacecraft. The requirement or sterilization based on our desire to attempt the detection of extraterrestrial life. This objective cannot be achieved if instrumentation is contaminated with terrestrial organisms. Likewise, we fail if we seed the planet with organisms and at some future date come back and redetect them. This problem has attracted wide interest in the scientific community.

The present requirement is that the possibility of landing a viable organism on Mars shall be 10^{-4}. This sweeping requirement affects all elements of the engineering task. For instance, the trajectory of the spacecraft for a Mars fly-by mission is determined by the miss distance, and therefore all the guidance and propulsion inaccuracies have to be related to this biological requirement.

The potential for the contamination of Mars is believed to be real. We must expect that Mars will support life until it can be shown to the contrary. Not only must the surfaces of the spacecraft be sterile, but the materials themselves must also be sterile. It is not adequate to sterilize only surfaces; a high velocity impa

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3/ NASA-CR-134. "Manned Environmental System Assessment." Office of Technical Services, Department of Commerce, Washington, D. C. (19

ll shatter and fragment the spacecraft over a wide area. The quirement that all materials in the spacecraft be sterile ans that parts such as transistors must be sterile, an expen- ve undertaking. For instance, a sterile television tube has en produced, but only some gyros can be sterilized by dry heat; hers must be sterilized by radiation. Sterilization cuts across erybody's business. All of the plastics, which we utilize so eely, harbor organisms, and the only way to reach these organisms with heat. Because electronics will not stand an autoclave, the esent solution is dry heat.

In order to achieve sterility, one must reduce the bacter- l load on the spacecraft. Thermal death curves are fairly well own for a wide variety of organisms and from these have been lected certain organisms that are quite heat insensitive as test ganisms for establishing the time-temperature requirements for y heat sterilization. Thermal death curves, however, depend upon e initial bacterial load. If the spacecraft is very "dirty," it kes more heat or a longer time than if it is quite clean.

The load reduction process means that the spacecraft must assembled under ultraclean conditions before the dry heat is plied. My group has been working with the engineers to set up e proper kinds of manufacturing and assembling facilities and ocedures so that the use of dry heat will be effective. After erility is attained, it must be maintained. This is accomplished encapsulating the vehicle, filling it with a gaseous sterilant, ch as ethylene oxide. This barrier must be preserved intact down the Cape, up on the launch pad, and all during launch to beyond r atmosphere, because the potential for contaminating the space- aft still exists to 300,000 feet. Many engineers say it can't done, but the attempt will probably be made.

As for the astronauts, thought has been given to steriliz- g the surface of the spacesuit which the man will wear when he goes t on the moon and when he comes in, but the process appears highly mplicated. Some action has been proposed related to the quarantin- g of the astronaut as well as quarantining of the specimens upon turn to earth. There are two schools of thought. One view favors otection of the astronaut. The other holds that the astronaut ould be utilized as the ideal culture material to bring back ex- aterrestrial life.

The inhospitable nature of the lunar surface and the com- exity of the sterilization process has led to abandoning the at- mpt to produce a sterile spacecraft directed to the moon. Perhaps number of the Ranger failures were related to the early steriliza- on attempts. The Soviets have reported that they used both heat d gaseous sterilants for their Venus probe. Although they re- rted entry into Venus, communications failed and there are no ta to show that they really had entered the planetary atmosphere her than trajectory information.

The main attention is now on Mars, and it appears reason- le that we might achieve the objective of sterility for the Mars obes. The Soviets appear motivated in this way, and the new

information exchange relationships established between us have this problem as a central one.

Sterility is a prerequisite for the detection of extra-terrestrial life. A gamut of methods for detecting life on other planets have been proposed and are being studied. Some of these methods present severe problems in sterilization. The proposed methods go from a simple culture device to electronic devices such as the flying spot microscopes to complex physical-chemical methods.

In all of space biology, no other area has excited as much interest as the possibility of detecting extraterrestrial life. The scientific community is particularly attracted to this problem, and the press has given it wide publicity. The social, cultural, and scientific implications are broad.

Dr. Lederberg[4/] has addressed himself to the core of the scientific interest of biologists in the possibility of extraterrestrial life. Simply stated, we have an opportunity to generalize our biological laws. The physicist can claim to universality of laws in the physical realm primarily as the result of the telescope. His observations of the planetary motions and such measurements as the speed of light permit the claim that the controlling laws are not unique to this earth, but are general for the universe. The biologist, on the other hand, has only terrestrial data. In the next 10 to 15 years we can look forward to obtaining another data point and a test of the hypothesis that life as we know it is a universal manifestation, at least in our solar system, or that it is unique to this planet. I can think of no more exciting event in the history of biological science.

4/ Lederberg, Joshua. "Exobiology: Experimental Approaches to Life Beyond the Earth." Science in Space, ed. L. V. Berkner and Hugh Odishaw, McGraw-Hill, 1961, p. 407.

PART II - PROBLEMS OF SCIENCE EDUCATION
REPORTS OF WORKING GROUPS

Attendance at the Philadelphia Conference was by invitation only. More than 135 college science instructors from 23 states participated in the conference and assisted in preparing the reports that follow.

Each participant was asked to identify his area of specialization and the group with which he would like to work. In almost every case it was possible to assign participants to the section of their choice. Each person was sent a preliminary report of each of three conferences which had been held at Detroit, Michigan; Tucson, Arizona; and Berkeley, California. Participants were asked to study these reports before attending the Philadelphia meeting and to work with the group of their choice in developing a conference report that would reflect their own thinking, as well as synthesize the reactions of the group reports from other meetings.

The reports that follow will show how effectively the groups carried out their assignments. They are presented with only a minimum of editing, in order to preserve the individuality of each group. It was not the intention of the groups or of the sponsoring organizations to formulate an official position or even to draft recommendations for approval by the NSTA or other organizations. The conclusions and recommendations are nonetheless an important record of thoughtful discussion and sincere effort to analyze present problems and to point the way to positive action for the future. The summary at the end of the reports attempts to bring together some pertinent observations and suggestions for further study.

GENERAL EDUCATION

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The Nature and Objectives of General Education Science

Interpretations and understandings concerning the nature of general education science for the non-science major are numerou and varied. These diversifications appear to arise from the multi tude of situations, conditions, and requirements that exist in the junior colleges. A synthesis of opinion indicates that foremost i the question: "What should general education science do for the student?"

General education science for the non-science major shoul enable him to develop certain competencies, such as making observa tions and the collection and analysis of data in the laboratory (when possible), in the classroom, and in his everyday life. It should assist him in developing appreciation and understanding by its inclusion of the significant philosophical, historical, and cu tural elementary of science through the integration of these with the goals of his primary academic interests. It should awaken him to selected principles and concepts of science which are so vital this age of computers, nuclear science, space travel, and cardiac surgery. It should assist the college in attaining its objectives by giving the non-science major a more meaningful realization of science so that he may be a more informed citizen.

A strong trend is apparent in the drift of general educa tion courses away from the traditional surveys of plants and anim in biology and the "watered-down" physics and chemistry offerings the past. This is concisely stated in a report of a recent Confe ence on Physics for the Non-Science Major, published in Newslette of the Commission on College Physics, and cited on pages 22-23 of this report.

Objectives of general education science for non-science m jors in the numerous junior colleges are widely diversified. They are dependent upon the objectives of the individual institutions, the course objectives formulated by their faculties, the instruc- tional facilities available, the transfer requirements of home-sta universities, the budget, the size of the student body, and the e perience, dedication, and background of those involved with the ac tual classroom instruction. The junior college of small or limite enrollment may find it necessary to offer introductory courses in

ience with a two-fold purpose, (1) the initiation of science train-
g for science majors and (2) the accomplishment of their general
ucation mission for non-science majors. Larger institutions fre-
ently find it convenient to separate science and non-science stu-
nts, but may or may not include laboratory experience in the
urses for the latter. Still other junior colleges, finding them-
lves in liberalized situations, experiment widely with innovations
a constant search for better courses and better methods of pre-
nting them. No attempt was made by this group to evaluate the
merous concepts of the many junior colleges in respect to their
ience for general education programs or to prescribe any one "type"
urse or program of science for general education. Rather, a con-
nsus of the group's opinion indicates that if a given program is
proaching the objectives outlined for their program and courses,
acceptable degree of success is undoubtedly achieved.

Objectives for science in general education for non-science
jors were listed in the Berkeley Conference Report and were approv-
by the group. These, with some modification are:

To help students see and comprehend the scientific phenomena about them

To show how scientists arrive at their views and to instill in students the means of applying these methods to daily problem solving, questioning, and inquiry

To present the effect of science upon our society

To recognize the basic unity of science by introducing inter-disciplinary approaches whenever possible

To show and to develop an appreciation for the esthetic values inherent in the field of science

A second set of similar objectives contained in Guidelines
r Science and Mathematics in the Preparation Program of Elementary
hool Teachers and produced as a joint effort of NASDTEC-AAAS are
tainable from the American Association for the Advancement of
ience.

w May Courses for Science in General Education be Implemented?

The objectives of an institution for its program of science
r general education determine its specific and detailed implementa-
on. Some kind of laboratory experience for the non-science student
s recommended by a majority of the group. Experiences in manipula-
ve activities, observation, the collection and interpretation of
ta, and the scientific reasoning process were indicated as the pri-
ry benefits to the student, even though such laboratory experience
ght involve laboratory activities not usually found in introductory
ience laboratory courses. Junior colleges unable to provide tradi-
onal types of laboratory experiences for students might well experi-
nt with innovations to accomplish equivalent results. Among the
ternative avenues for the latter institutions are a variety of ap-
oaches including the use of modern audio-visual techniques, including

"close-up" television viewing wherein the critical details of demonstrations and even microscopy may be presented clearly and accurately to large groups of students. The audio-tutorial method which enables students to use initiative and imagination while working at speeds consistent with their abilities has received wide acclaim. Junior colleges which have the capability of developing programs involving this method may anticipate and achieve outstanding success.

What Problems Confront Junior Colleges in Respect to Science for General Education?

1. In respect to faculty, what specific training and background is essential, what should be the faculty member's subject-matter orientation, how may he remain up-to-date academically, and how may he maintain professional association with junior college an senior college colleagues?

2. In respect to facilities, where may junior college science instructors obtain assistance in planning laboratories, classroom and audio-visual aids and assistance in evaluating and selectin equipment?

3. In respect to transfer of students to senior colleges: Should junior colleges pattern their offerings after those of senior colleges to which their students transfer? How may junior colleges communicate and articulate with senior colleges? Should transfer and terminal junior college students be offered course at the same level or similar courses and different levels of academic quality?

4. In respect to communication, how may junior college faculties maintain liaison?

Recommendations:

1. In respect to faculty: Requirements differ for the selection and certification of junior college faculty, but strong subject matter background with an orientation toward teaching is indica ed. Research, however modest, must be encouraged (even if not required) since this medium and the professional association it stimulates are of inestimable value in remaining up-to-date and maintaining contact with colleagues. Faculties must be given freedom in the development of objectives and in the selection o the means of obtaining them.

2. In respect to facilities: Faculties should be consulted early in the planning of facilities within the limits of budgetary considerations and the over-all objectives of the college. Assistance in planning facilities is available through visits to new buildings on nearby campuses, professional societies such a the facilities information service of the American Association of Junior Colleges and vendors of laboratory and audio-visual equipment. Funds spent for adequate and long-range planning of facilities cannot help but achieve successful and lasting resul

3. In respect to transfer of students to senior colleges: Persiste

and continued contact should be maintained with senior colleges in order that junior college programs and courses may achieve smooth and equivalent transfer. Articulation can be successful only if constant and adequate efforts persist.

In respect to communication: Junior college instructors have increased in number to the point where they constitute a major segment of the total of college and university personnel. Media to maintain liaison, cooperation, and communication among them at the instructional level generally are lacking. A recommendation, approved unanimously, indicates the desirability and the need for a publication source to which junior college instructors may refer for the exchange of ideas, information, and the results of experimentation pertaining to science in general education for the non-science major. Since the initiation of a new journal or some form of a newsletter does not seem practical or feasible at this time, space in such journals as the Junior College Journal, or The Science Teacher (the journal of the National Science Teachers Association) should be sought.

In summary, it may be stated that science in general educa-
on for the non-science major consists of a core of experiences,
nciples, and competencies which relate science to daily living
which make the student a more informed citizen. The specific
ails of courses in science in general education are determined
marily by the objectives and goals of the college, the particular
erests, backgrounds, and objectives of the participating faculty,
limitations of the college facilities, budget, and enrollments,
the characteristics, goals, and needs of the students being
ght.

PROBLEMS OF TRANSFER STUDENTS

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General Comments by Chairman

Of the 21 persons attending this discussion group, 13 were from public institutions, and 7 were from private junior colleges. There was only one member in this discussion group who had attended one of the other sessions, either at Berkeley, Tucson, or Detroit.

Of the conferences sponsored up to this time, this was the first discussion group basically concerned with problems of transfer students. Since the majority of the members of the group were new and the topic was new, there was little attempt by the group to deal with the problems in depth. We dealt with only a few problems that came to mind. This is by no means a complete report on all the problems involved in the transfer of students.

It was suggested by a number of participants that at future meetings, groups first divide into private and public institution groups and later reassemble to discuss common problems of both types of institutions.

Outline of Points Discussed by the Discussion Group

1. On advising students concerning their transfer courses, where can faculty advisors get information on programs relating to four-year curriculum requirements? Further, where can information be obtained concerning the availability of monies, scholarships, etc?

   Suggested solutions:

   (1) Develop and maintain an up-to-date, centralized library. The library should consist of (a) college catalogs, (b) professional organizations' materials, (c) federal agencies' materials, such as Occupational Outlook Handbook, (d) professional materials, such as Comparative Guide to American Colleges by James Cass and Max Bernbaum; The College Blue Books; American Universities and Colleges by the American Council on Education, etc.

   (2) Professional people in the particular science fields should be consulted.

   (3) Counseling services within the college should be consulted.

(4) There should be more national, regional, and state conferences, workshops, and institutes on career information for counselors and faculty advisors. Some of these conferences, workshops, and institutes should be sponsored by the junior colleges for junior college personnel.

There is a lack of articulation among junior and senior institutions of higher learning.

Suggested solutions:

(1) There should be better communication and understanding among administrators of types of institutions of higher learning; both formal and informal communication methods should be used.

(2) There should be better communication and understanding among science faculties of types of institutions of higher learning, also using both formal and informal methods.

(3) Everyone associated with the junior college should educate the four-year institutions and the public that the junior colleges are in fact two-year colleges with the responsibility of imparting knowledge at the same level of vigor as the four-year institutions.

(4) All types of institutions of learning should share course outlines and notify each other of any changes.

(5) Junior college faculty members should participate in professional organizations and become involved in the solutions of problems germane to both types of institutions.

Senior college and university science faculties seem to feel that the junior college faculties over-rate the academic abilities of their students.

Suggested solutions:

(1) There should be a measuring instrument instituted that would evaluate the achievement level of students in all lower levels in both junior and senior institutions. Particularly, it should be used at the beginning of the junior year or the end of the sophomore year.

(2) Junior colleges should make follow-up studies on all transfer students. From results of such studies, comparisons of achievement should be made with the students who did all of their work at the four-year colleges, similar to A National Study of the Transfer Student by Dorothy M. Knoell and Leland L. Medsker.

There appears to be a lack of openings at senior colleges and universities for the average science major student.

Suggested solutions:

(1) Senior institutions must recognize the problem and

enlarge their present facilities to accommodate more students.

(2) Senior institutions not now offering science programs should offer science curriculums leading to a baccalaureate degree.

(3) There should be science branches of senior colleges and universities located on or near junior college campuses

(4) There should be better guidance of students at the secondary and the junior college level with regard to transfer information.

SCIENCE FOR TECHNICIANS

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chnical programs should consider transfer potential where possible.

A flexible curriculum should be offered to enable those th transfer potential to pursue advanced study with minimum loss credit. At the same time, those capable of developing occupation- competence in a technology should not be eliminated from success- l completion of the program because of an attempt to make it a iversity parallel course. Steps should be taken to change four- ar college and university attitude toward the non-acceptance of alified two-year college graduates with appropriate transfer edit. University faculty should be invited to two-year colleges acquaint them with the quality of the course work and to improve nes of communication. Two-year colleges should conduct surveys the success of transfer students in advanced programs to evaluate e transfer potential of the technical curricula. An effective unseling center and departmental advisory program should be estab- shed to aid the student in deciding on transfer or career possi- lities.

re effective use should be made of the opportunities offered rough the tremendous need for technicians in scientific areas.

Two-year colleges and industry should cooperate in acquainting the public of the professional, financial, and advancement opportunities in employment as technicians.

A concerted advertising effort should be made, using radio, television, and the press toward this end.

Continuing effort should be made in acquainting parents, students, and high school counselors with the professional status of the technician.

The above groups should be made aware of the fa . that the responsibilities given to technicians today are similar to those given to engineers ten to twenty years ago. Many students who enroll in bachelor's degree programs fail to realize that the associate degree program may be more effective in preparing them for the career they have in mind.

High school counselors should be invited to conferences at

two-year colleges so they may become aware of the career opportunities in technology.

Programs in technical science can be made more effective.

A course in a technical science must be an ever-evolving, resynthesized one to keep pace with the changing needs of technolo and the changing qualifications and capabilities of the students i the program. An outstanding feature of a technical science curric ulum is the strength of the laboratory program as an important instructional area. The laboratory should be taught by the professo with careful planning toward programing the instruction with appro riate emphasis on the development of techniques and methods. Labo atory instruction should be up to date, with well-equipped, modern equipment. Laboratory teaching loads should be equated on a par with lecture teaching loads. Each technical curriculum should mak effective use of an advisory committee representing the scientific industries.

Each faculty member involved in teaching a technical science should make frequent field visits to become acquainted with t changes in technology. Faculty leaves should be granted to permit field experience to aid in the development of courses of study. T accommodate the need for developing an understanding of theory and principles as well as application, greater use should be made of visual aids. Each college should have an audio-visual director with technicians to aid in the preparation of instructional materials or should be a participating member in an audio-visual cente from which such materials would be available. Every technical curriculum should have an appropriate balance of courses in general education to truly educate the student. All science and mathematic departments should willingly design and redesign courses of study meet the needs of students in technical curricula.

Where high school graduates lack the prerequisites to begin technical curricula, the college should offer appropriate courses in these prerequisites in evening or summer sessions. Thes colleges should also offer courses in an extension program to retrain industrial personnel.

PROBLEMS OF STUDENTS WITH POOR BACKGROUNDS

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Mathiston, Mississippi

Kathryn P. Caraway, Recorder
Flint (Michigan) Community Junior College

Ethelreda Laughlin, Resource Person
Cuyahoga Community College
Cleveland, Ohio

This topic was also mentioned in the Detroit conference, there were special groups who discussed "Students with Poor ‹grounds" at both the Tucson and Berkeley meetings. The group the Philadelphia conference represented the areas of biology, nistry, geology, physics, and physical science. The majority of participants represented colleges with the open-door policy. discussion centered around the following eleven questions:

Do we have well-defined background requirements in the various areas?

All agreed that an adequate reading level was necessary. One college reported some remedial reading is required if a student scores low on the SCAT test. One college requires that a student be eligible for the regular college English before he can enroll in biology. This was the only college with a specific prerequisite expressed for biology.

All agreed that some math course was a prerequisite for chemistry. Many schools require high school chemistry as a prerequisite for the chemistry course for the various pre-professional students. Many colleges are now requiring that the student validate his high school training by a placement test. Most were using the Toledo Placement Test.

Some colleges require trigonometry in high school or concurrently with the general physics course. Many offer physics concurrently with the second or third semester of a calculus series. Some colleges offer physics only at the sophomore level; therefore, the first year serves as a "weeding out" of the poor students. Some colleges also offer the equivalent of a high school chemistry and physics course on a non-credit basis.

One college has established a "diploma" which can be granted to the student who has taken many hours of remedial or make-up classes but who cannot perform in the regular college courses. Some colleges require that make-up work be done in the summer preceding the fall admission. One college requires summer make-up based on college board scores. The student is permitted to take three classes. If he does not make satisfactory improvement, he is denied fall admission. About 50 out of 300 are required to take this work.

2. Can we identify the student with ability and poor background?

Many schools have a cutoff point established for some standard tests such as SCAT or ACT. It was pointed out that we must be flexible enough to consider the student who scores poorly but is recommended by the high school counselor. The group reported varying experiences. Some members felt they could not rely on counselors' recommendations; some felt that they could. Perhaps it depends upon the local situation, and the college should attempt to work closely with the high schoc

3. What remedial courses are needed for the student with ability but a poor background?

It was agreed that English and mathematics are the two important basic skills. Many students with ability need help in learning to read with comprehension at a high rate of speec One college has developed a learning laboratory. The student works at his own pace on reading, writing, and arithmetic; hov ever, this is concurrent with his college program which may be reduced because he is scheduled for considerable time in the laboratory.

It was agreed that reading is the most important skill needed by all students. In mathematics, fractions, decimals, exponents, and radicals seem to cause the most trouble.

In a discussion of grade requirements in order for a student to move to the next higher course, it was agreed that a course in the transfer program require the minimum of a "C" grade in sequence courses.

4. What new techniques in teaching have been tried or are being tried now?

One new college is planning to do most of the teaching through programed instruction. It is presently using commercially available programs, but plans to write its own programs One college reported using TV as another means of reinforcemen and found that color TV seems to get more attention from the student. However, if the TV is made optional, few students ta advantage of the material.

Some colleges are using the CHEMS films, which are available in cartridge form and, thus, are easy for students to use These can be used with a pretest, study outline, and then a post-test. El Camino Junior College is carrying on such a project.

It was mentioned that Bell Telephone Company has some ver good films in physics and genetics and that film loops or single-concept films are being used. It was agreed that a fil evaluation source for films at the college level would be very helpful.

5. Is a physical science course a good approach to the correction of deficient backgrounds?

Most participants felt that physical science courses are designed to stress concepts of the physical sciences for the non-science major and that this was not a remedial or repair approach.

One college reported that it was trying an intradisciplinary approach in which it was attempting to help the student realize that English writing was for science as well as for English class and that math was important and useful out of the math room.

What is the responsibility of the science area to the student with poor ability?

A number were against offering low-level courses but felt that we must recognize that this student will be a terminal student and offer him as much as possible, but not teach high school-level courses. However, many of the participants favored a several-track program for the college and placement of the student according to his ability.

Can we successfully establish tracks for students, and should there be a track which has no science requirement?

It was agreed that a college transfer science program and a terminal program can exist side by side. It may also be necessary to have a vocational or career type science program; this will depend upon the philosophy of the particular college. The terminal and career courses should not be lower level but should be courses especially designed for a particular set of students.

We should realize that it frequently takes time for a student to get on the correct track; it should be easy for a student to transfer from one track to another. We must keep in mind that parental pressure often forces a student to attempt something beyond his ability.

It was agreed that good guidance is needed as early as the junior high school level. Guidance counselors should be made aware of the requirements for all programs. Many seem to realize that math is needed for transfer college science programs but do not advise career students to study as much math as possible.

It was agreed that a good terminal science course for non-science majors could be based upon the history and philosophy of science.

The next topic for discussion centered around the need for greater liaison between the guidance and science departments.

It was agreed that at least one science instructor should receive released time to serve as a coordinator for science advisement. The group felt that science advisement should be available for evening students.

The group also discussed class loads for instructors an felt strongly that laboratory hours should be counted on a one-to-one relationship.

9. The question was raised about the evaluation of the success th: students in the lower-track science courses.

It was agreed that transfer and terminal (non-science m courses are evaluated by the senior colleges and that indust evaluates the career courses.

The group felt that both essay and objective tests shou be used in testing progress in a course. Students with poor backgrounds would probably receive the most help, if their writing mechanics could be checked. They usually need to be made aware that writing skills are needed in science classes Most of the group members agreed that deduction of points fo errors in writing did cause the student to take more interes in these matters.

10. Does the actual schedule of classes have an effect on the su cf the poorly prepared student?

It was generally agreed that these students should be scheduled with some breaks between classes regardless of the student's wishes. He cannot perform best if he takes four classes in a row and has no break.

It was also mentioned that some of these students with backgrounds are a result of a cultural deprivation. This ma occur in large urban cities or small, fairly isolated commun Perhaps intradisciplinary courses are a partial answer to th problem.

11. Should colleges establish courses to meet special needs of industry?

In the keynote address, J. O. Luck, Head, Education and Training, Murray Hill (New Jersey) Laboratory, Bell Telephon Company, stated that he did not think that colleges should s up particular programs or courses to satisfy a particular in dustry. The majority of the group felt that a college shoul establish a program or course if there was a local need and industry could absorb all of the graduates of the program. dustry should make clear the area of content and serve as an advisor, but the details of content should be established by the college faculty. This is no different from that which i done for nursing and programs for dental assistants.

If there is a need for a particular course so that stud can upgrade themselves in a particular industry, the science partment should attempt to make the course available; but th college should accept advice, and the college staff should direct the content of the course.

nary of pertinent points:

The student with poor background and good ability and the student with poor background and poor ability should be identified.

Remedial reading, writing, and arithmetic should be established. Remedial courses should be completed before the college courses are pursued. Courses in speed reading may be needed by well-prepared students.

Several tracks should be established. Science courses should be offered for transfer students, for terminal (non-science majors), and for career (vocational) students. These courses should have clearly defined objectives and be planned to meet the needs of a specific group of students.

A science instructor should receive released time to work on guidance for students in the science area. There should be a close liaison between junior high and senior high school for guidance in the science area.

Laboratory hours should be counted on a one-to-one basis in determining the faculty load.

We should study the use of new techniques such a programed instruction and intradisciplinary courses in all phases of teaching but particularly for the remedial courses.

There is a need for a good source for film evaluation at the college level.

Physical science courses are not designed for remedial work but, rather, for the non-science major.

Colleges should establish programs or courses required by a particular industry, but the college faculty should determine the content with advice from the industry.

Students with poor backgrounds should be scheduled so that all classes are not consecutive, but that the students have frequent breaks for best performance.

The question raised at the general summary meeting should be considered: Should we have the same entrance requirements for the older, more mature student in the science area?

LABORATORY FOR THE BIOLOGICAL SCIENCES

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The General Biology Course

The aims of the general biology course for liberal arts and biology transfer students (biology majors) are the same. Because of different student backgrounds and deficiencies in prepar tion, it may be necessary to give separate courses. It was the opinion of most members of the group that the terminal nursing pr gram requirements are so specific at present that they often requ a special course for the program. Where the existing biology cou fulfills the nursing requirements, it is recommended that the nur take the regular course.

The subject of teaching general biology rather than bota and zoology was discussed. General biology is taught in approximately 50 percent of the schools represented by the group. In fo schools, a one-semester course in cell biology is followed by bot and/or zoology.

An honors course in biology was strongly recommended. T should be prerequisites--one previous year of biology with a "B" age was suggested. Some advanced honors courses are seminar type which carry variable credit.

Laboratory Requirement for All Biological Sciences

The group strongly endorsed a laboratory for all biology courses. The majority feels that there is better laboratory lear ing where the laboratory is integrated with the lectures. The op ended laboratory investigation was recommended, particularly for better student.

There should be no more than 20 students in any laborato section.

Emphasis on Molecular Biology

It was felt that liberal arts and terminal students need less emphasis on molecular biology than does the biology major. Where background deficiencies exist, some preliminary chemistry i given as part of the biology course. Students with good high sch preparation might be placed in an advanced course on the basis of

ir performance on a placement test.

io-visual Aids, Programed Instruction, Audio-tutorial Programs

The instructor should choose the type of audio-visual mate-ls he wishes to use in conjunction with laboratory work. The use tapes and modified programed instruction can be profitable for dent make-up and review.

The audio-tutorial method is a highly structured approach may not necessarily be a more economical way of presentation large numbers of students in contrast to the more traditional oratory work. It provides for efficient, independent work where ff and space considerations permit.

ching Load

Equal credit should be given for lecture and laboratory k, hour for hour, in determination of the instructor's schedule. addition to the limit in clock hours, consideration should be en to the number of preparations, administrative duties, etc., extra reimbursement should be given for extra hours. A total d of twelve contact hours is recommended, with fifteen as maximum.

logy Laboratory Facilities

The biology faculty should be consulted in regard to plan-g laboratory space. There should be prior consultation with the hitect, and final approval should be the responsibility of the ulty involved. The long-range program should be considered when ns are made so that a maximum of flexibility is allowed. Separ-laboratories for advanced courses are recommended. Animal rooms a greenhouse are considered necessary. These should be adequate-supervised.

It is recommended that periodicals and appropriate reference ks be kept in the laboratory for student use; it has been shown t there is less book loss and more student use when these mate-ls are in the laboratory. Reprints may also be used in this way. re should be duplicates of these materials in the library.

oratory Assistants

Laboratory assistants are necessary and should be well pared. These assistants might include both student aides and tructional and technical assistants. They should not be con-ered replacement for adequate teaching faculty. The number of istants should be adequate for the number of faculty and the ber of students in the laboratory.

LABORATORY FOR THE PHYSICAL SCIENCES

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Laboratory work is a vital part of any science course. But the non-science major especially needs a kind of laboratory experience different from that of most current courses. He needs to think his way through and to appreciate the great concepts of science; he should know how these concepts evolved and were teste

Such a course should:

1. Use an interdisciplinary approach
2. Follow the historical development of the concepts of science
3. Be based on extended laboratory projects of three to five weeks each
4. Use projects which have a quantitative basis
5. Guide the student through the methodology of science in his investigations
6. Consider in depth the important conceptual schemes of science
7. Present science as a stimulating subject, intellectually satisfying, and significantly related to life experiences

The laboratory project need not require great technical skill or expensive equipment. It should be organized over a subj matter area and be of the "open-end" type. Flexibility is needed both for the time available for the project and for the specific kind of experimental work to be done. Application of appropriate graphic techniques can simplify the mathematics used. (One reference for such projects is The Laboratory Approach to the Physical Sciences by C. E. Ronneberg, et al., Houghton Mifflin, New York. 1965. 157 pp.)

This broad approach to laboratory work, with its emphasi on student involvement with scientific concepts rather than on de tailed laboratory workbook procedures, should be even more effective in the regular physics and chemistry courses for science maj It is recommended that such an approach be tried in these classes

Another topic discussed was that of the use of complicat

truments and special techniques in advanced courses. It was eed that the "black box" approach should be avoided.

The comparative value of teaching descriptive chemistry cts) vs. theory was discussed. It soon became apparent that no ber of the discussion group held that either descriptive chemry or theoretical chemistry alone was of much value. Rather, is important to use the facts of chemistry to develop the ories of chemistry so that the student will understand the con- ts of chemistry. This idea was extended as the multilevels of entific concepts: facts at the lowest level, methods added at intermediate level, and principles and philosophy included on upper level.

This group also considered how the teacher might be able find time to make these improvements in laboratory teaching. recommendations received emphatic support:

For teaching-load computation, one hour of laboratory should equal one hour of lecture.

Enough paid clerical and laboratory technical help should be available so that the science teacher is free to spend his time teaching.

CONCLUSIONS

There are several areas of agreement among the various w sessions that should be considered significant in planning scienc programs. There was almost unanimous agreement among the particip that:

1. Science cannot be taught effectively without laboratory work. This work should not follow the traditional "cookbook" experi ments so commonly found in laboratory manuals. It should rep resent new, imaginative, open-ended experiments that will cha lenge the students to think and help them to understand what science is really like.

2. Laboratory work, properly conducted, is as demanding on the i structor's time as are lecture sessions. Work load should be computed on a clock-hour, rather than a credit-hour basis. A it is important that instructors be provided adequate laborat assistants to supplement, but not to replace the instructor's responsibilities.

3. There is an increasing need for emphasis on principles, rathe than on facts. Individual bits of information should be used as a means to the end of making generalizations and understan ing principles, and not as an end in themselves.

4. There is a need for constant course revision and improvement. No one course can be considered acceptable for every institu- tion, and instructors should be encouraged to develop new and imaginative courses that reflect their particular capabilitie and yet provide an adequate understanding of science. This i particularly essential for general education courses, which have generally been unimaginative and unsatisfactory. In spi of all daydreams to the contrary, there is no probability of discovering an ideal course of study that can be adopted as a permanent part of the curriculum of any institution.

Junior college science instructors appear to be willing and active in developing new programs and updating content. Thes activities should provide a stimulus for instructors in four-year colleges and universities to expend more effort to modernize thei curriculum so that the two-year colleges will not find themselves hampered in their progress by outmoded restrictions in the senior institutions. There is some evidence that efforts on the part of junior colleges to meet the requirements of four-year institution may be hampering change. For example, in spite of the general agreement on the value of consolidating traditional courses in biology, some schools still feel compelled to retain the traditio al zoology-botany approach.

Junior college instructors appear to reflect much more c cern for the individual student than do instructors in some four- year institutions. The attitude of the junior college instructor seems to be "let's do our best to give the students a chance" in- stead of "let's flunk out the low achievers and get rid of them."

There is a reassuring evidence of the competence and pro-
sional attitude of the junior college instructor. The two-year
lege is here to stay, and the percentage of underclassmen who
l get their education in these institutions will continue to in-
ase. The quality of the junior college provides a challenge to
four-year colleges and universities to work harder to maintain
ir role of leadership in higher education.

There was pervasive evidence of the need to provide two-
r college science instructors with better means of communication
more opportunity to discuss mutual problems. The National Sci-
e Teachers Association is trying to determine what it can do to
ve this group more effectively. As a part of this effort, NSTA
planning to hold more conferences in various sections of the
ntry to provide the opportunity for more interchange of ideas.
you are interested in attending some of these conferences, you
obtain further information by writing to the National Science
chers Association, 1201 Sixteenth Street, N. W., Washington,
C. 20036.